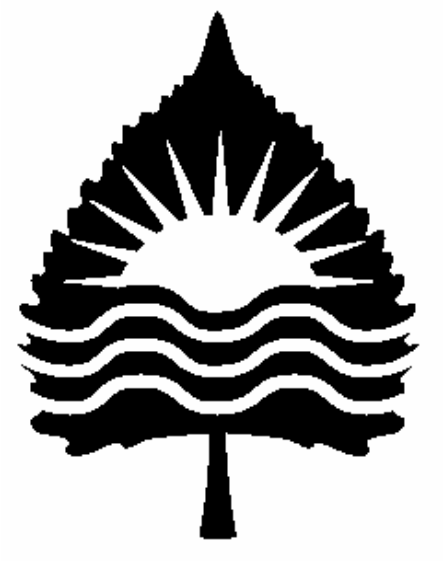

Total Maximum Daily Loads
for
Standing Bear Lake – Douglas County, Nebraska

Parameters of Concern: Siltation/Sedimentation, Dissolved Oxygen and Nutrients

Pollutants Addressed: Sediment and Phosphorus

Nebraska Department of Environmental Quality
Planning Unit, Water Quality Division

June 2003

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Executive Summary

Standing Bear Lake was included on the 1998 Nebraska Section 303(d) List of Impaired Waters (NDEQ 1998) due to impairment by low dissolved oxygen/organic enrichment, arsenic and pesticides (atrazine). The waterbody has been listed on the 2002 Nebraska Section 303(d) list (NDEQ 2002) due to impairment by siltation/sedimentation and nutrients as well; low dissolved oxygen has been identified as a water quality concern. As such, a total maximum daily load (TMDL) must be developed for each impaired parameter in accordance with the Clean Water Act. This document presents TMDLs for sediment; nutrients (i.e., phosphorus) and organic enrichment/low dissolved oxygen, designed to allow Standing Bear Lake to fully support its designated uses in addition to water quality goals established through the Community Based Watershed Planning Process (COPRPP 2000). The information contained herein should be considered 3 TMDLs that target 2 pollutants. Specifically, sedimentation has been targeted to address the siltation impairment and phosphorus is the pollutant targeted to address the nutrient and organic enrichment/low dissolved oxygen impairments.

Revisions to Title 117 – Nebraska Surface Water Quality Standards criteria and a reassessment of the water quality data has allowed for the de-listing of Standing Bear Lake for impairment caused by pesticides (atrazine) and arsenic, therefore it is not necessary to address these pollutants. The de-listing is included on the approved 2002 Nebraska Section 303(d) list.

These TMDLs have been prepared to comply with the current (1992) regulations found at 40 CFR Part 130.7.

1. Name and geographic location of the impaired waterbody for which the TMDLs are being developed.
Standing Bear Lake, Section 22, Township 16 North, Range 12 East, Douglas County, Nebraska, Lat. 41° 20’ 10”, Long. 96° 08’ 13” (center of dam).

2. Identification of the pollutant and applicable water quality standard.
The pollutants causing the impairment(s) of the water quality standard and designated beneficial uses are sediment and nutrients (phosphorus). Designated uses assigned to Standing Bear Lake include: primary contact recreation, aquatic life Warmwater class A, agriculture water supply class A and aesthetics (NDEQ 2002). Excessive sediment and nutrient inputs have been determined to be impairing the aesthetic and aquatic life beneficial uses. In regards to aquatic life, the applicable dissolved oxygen criterion has been deemed impaired based upon excessive nutrients.

3. Quantification of the pollutant load that may be present in the waterbody and still allows attainment and maintenance of the water quality standards.
Bathymetric survey data, and the GWLF and EUTROMOD water quality models were employed to determine the current and maximum sediment and nutrient loads that if achieved should result in beneficial use attainment. These values are 10,000 tons/year and 779 lbs/year sediment and phosphorus, respectively

4. Quantification of the amount or degree by which the current pollutant load in the waterbody, including upstream sources that is being accounted for as background loading deviates from the pollutant load needed to attain and maintain water quality standards.
Based on 1998 watershed conditions the average annual sediment load of ~4,544 tons/year is below the 10,000 tons/year average needed to meet the annual volume loss target.

The total phosphorus load delivered to Standing Bear Lake is estimated to be 1,191 lbs/year. To achieve beneficial use attainment and meet the water quality goals, the loading capacity is estimated to be 778 lbs/year. To achieve this loading capacity a 37% (428 lbs) reduction from the watershed is needed.

5. Identification of the pollutant source categories.
Nonpoint sources of sediment have been identified as the cause of the siltation/sedimentation impairment to Standing Bear Lake. Nonpoint and natural sources have been identified as the cause of the nutrient and dissolved oxygen impairment to Standing Bear Lake.

6. Wasteload allocations for pollutants from point sources.
No point sources discharge in the watershed and therefore the wasteload allocations will be set at zero (0).

7. Load allocations for pollutants from nonpoint sources.
For these TMDLs the sediment and phosphorus load allocations were set at 4,544 tons/year and 745 lbs/year, respectively. These allocations were developed using models and empirical data. No specific sediment load allocations were made for natural sources as allowed by 40 CFR Part 130.7. The phosphorus load allocation for natural sources is 33.7 lbs/year and was also determined using the EUTROMOD model.

8 A margin of safety.
These TMDLs contain explicit margins of safety (MOS) for both sediment and an implicit margin of safety for phosphorus. For sediment, the difference between "expected" and "allowable" loads has been allocated to the MOS with the inclusion of a specific percentage for future growth. In regards to phosphorus, pollutants are discharged from the system via the reservoir's outlet. The TMDL will assume all pollutants delivered to the waterbody remain, again reflecting a worst-case condition.

9. Consideration for seasonal variation.
The pollutants of concern are delivered on a year round basis and the assessment of the data considers annual average conditions. However, in-lake and watershed model inputs require that seasonal changes (e.g. vegetative cover, precipitation) be accounted for. Because nonpoint sources have been identified as the largest contributor, management practices and implementation will be targeted at those times when the nonpoint source influence is the greatest. This usually revolves around the precipitation events of mid to late spring when there is a high potential for run-off of sediment, phosphorus (attached to sediment), and nitrogen. The effects of the excess pollutant loadings are: large quantities of algae growth occurring during the growing season, potential for future dissolved oxygen impairments and sediment reducing the volume of the lake.

10. Allowances for reasonably foreseeable increases/decreases in pollutant loads.
Allowances were made for future growth and included in the MOS for the sediment TMDLs and no allowance for future growth was identified in the nutrient TMDL

11. Implementation Plan.
Although not required by the current regulations, an implementation plan (COPRPP 2000 – see attached copy) has been developed to address the sediment and phosphorus loading reductions necessary to meet established water quality goals and criteria. This implementation plan was a product of a Section 319 "Community Based Watershed Management Plan Project" sponsored by the City of Omaha Parks, Recreation & Public Property Department.

The TMDLs included in the following text can be considered "phased TMDLs" and as such are an iterative approach to managing water quality based on the feedback mechanism of implementing the required monitoring plan that will determine the adequacy of load reductions to meet water quality standards and revision of the TMDL in the future if necessary. A description of the future monitoring (Section 5.0) that is planned has been included.

Monitoring is essential to all TMDLs in order to:

- Assess the future beneficial use status;
- Determine if the water quality is improving, degrading or remaining status quo;
- Evaluate the effectiveness of implemented best management practices.

The additional data collected should be used to determine if the implemented TMDL and watershed management plan have been or are effective in addressing the identified water quality impairments. As well the data and information can be used to determine if the TMDLs have accurately identified the required components (i.e. loading/assimilative capacity, load allocations, in lake response to pollutant loads, etc.) and if revisions are appropriate.

1.0 Introduction

Standing Bear Lake was listed on the 1998 Nebraska Section 303(d) list of impaired waters (NDEQ 1998a) as not supporting the assigned beneficial uses with the pollutants of concern being, organic enrichment/low dissolved oxygen and atrazine (pesticides). Standing Bear Lake has been listed on the 2002 Nebraska Section 303(d) list of impaired waters (NDEQ 2002) due to impairment by siltation/sedimentation and nutrients. Low dissolved oxygen was also identified as a water quality concern.

For the 1998 atrazine listing, the applicable water quality criteria applied was 1 µg/l, which was intended to protect aquatic life during chronic exposures. In 1999, the Nebraska Department of Environmental Quality (NDEQ) proposed and received approval to change the chronic water quality standard found in Title 117 – Nebraska Surface Water Quality Standards (Title 117) from 1 µg/l to 12 µg/l. Using this new standard, the NDEQ's assessment procedures and the existing data, Standing Bear Lake was re-assessed and determined not to be impaired due to atrazine. Therefore, for the 2002 Section 303(d) listing, the parameter has been removed and no total maximum daily load (TMDL) will be developed for atrazine.

Similarly, in 1999 the chronic water quality standard for arsenic was changed from 1.4 µg/l to 16.7 µg/l. Using the modified arsenic standard, assessment procedures and existing data, the waterbody was re-assessed and determined not to be impaired due to arsenic. This parameter was also delisted in 2002 and no TMDL will be developed for arsenic.

In reservoirs, dissolved oxygen impairments can be the result of accelerated eutrophication. Excessive algae and macrophyte growth add to the oxygen demand. Control of the nutrients should in turn have an affect on the plant growth, which then will affect the oxygen demand. Therefore, based on the above and as required by Section 303(d) of the Clean Water Act and 40 CFR Part 130.7, TMDLs for sediment and nutrients have been developed and contained herein to address the siltation/sedimentation, organic enrichment/low dissolved oxygen, and nutrient impairments.

1.1 Background Information

Standing Bear Lake, a 137-acre reservoir located in Douglas County, Nebraska, was constructed by the U.S. Army Corps of Engineers (USACE) in the mid-1970s primarily for flood control with recreation as a secondary benefit (Figure 1.1). Physical description information for Standing Bear Lake is presented in Table 1.1. Historically, eastern Nebraska has sustained the majority of the state's population while western Nebraska has contained most of the recreational lands. As a result, lakes located in eastern Nebraska are extensively used and have become important recreational resources.

1.1.1 Waterbody Description

1.1.1.1 **Waterbody Name:** Standing Bear Lake

Lake Identification Number: MT1-L0100 (NDEQ 2002, Title 117 – Nebraska Surface Water Quality Standards)

1.1.1.2 **Major River Basin:** Missouri River, Code 09

1.1.1.3 **Minor River Basin:** Lower Missouri River, Code 12

1.1.1.4 **Hydrologic Unit Code:** 10230006

1.1.1.5 **Assigned Beneficial Uses:** Primary Contact Recreation, Aquatic Life Warmwater Class A, Agricultural Water Supply Class A, and Aesthetics (NDEQ 2002).

1.1.1.6 Major Tributary(s):

Standing Bear Lake was constructed on two unnamed tributaries of Big Papillion Creek in Douglas County, Nebraska.

Figure 1.1 Location of Standing Bear Lake's Watershed in Omaha, Nebraska

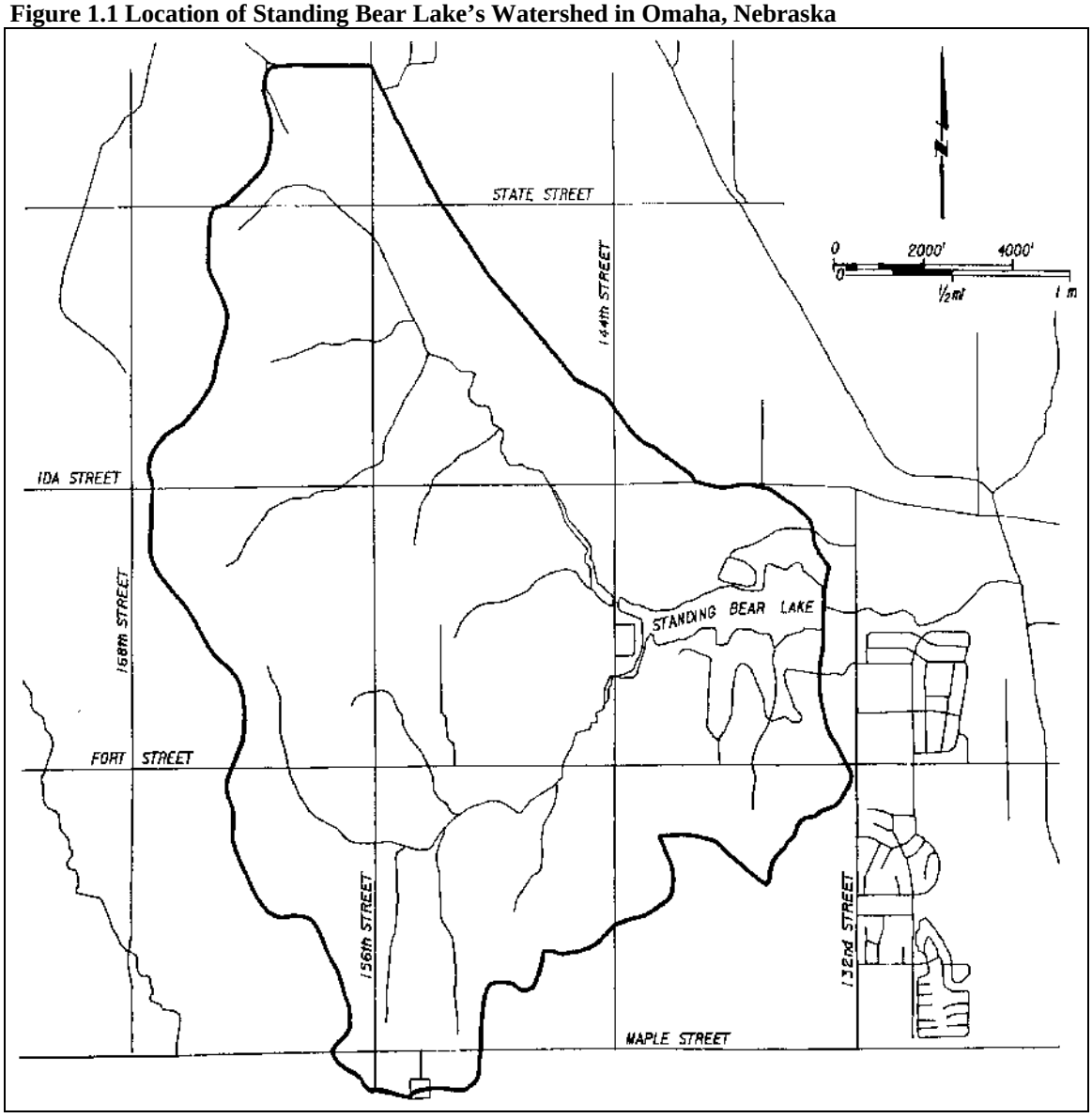

Table 1.1 Physical Description of Standing Bear Lake

Parameter	Standing Bear Lake
State	Nebraska
County	Douglas
Latitude (center of dam)	41°20'10"
Longitude (center of dam)	96°08'13"
Section, Township, Range	Section 22, Township 16 North, Range 12 East
Surface Area - 1972	137 acres (speculate volume was calculated from topographic map)
Surface Area - 1998	104 acres (perimeter surveyed in 1998)
Mean Depth - 1972	10.9 feet
Mean Depth - 1998	12.0 feet
Volume - 1972	1,504 acre/feet
Volume - 1998	1,249 acre/feet
Number of Major Inlets	3
Watershed Area	3,840 acres
Lake to Watershed Area Ratio	1:28

Source: (JJM 1992 and NDEQ 1998b)

1.1.2 Watershed Characterization

1.1.2.1 **Physical Features:** The Standing Bear Lake watershed covers 3,840 acres and is located in the low plains ecoregion in east-central Nebraska (JJM 1992). The reservoir was completed in 1972, and the dam structure was closed in 1977. Development in the watershed has been in continual transition from agricultural to urban land uses since this time.

The Standing Bear Lake watershed is characterized as having a rolling terrain and steep slopes. Two primary streams drain into the west end of the lake. Sedimentation basins have been constructed on these tributaries to detain runoff and remove suspended solids/nutrients. The basin on the southwest side Standing Bear Lake is known as Grade Stabilization Structure D-18 and was completed in 1990. This basin drains ~1,053 acres of the watershed and had an initial volume of 81.4 acre-feet. By 1999, the volume had been reduced to 41.6 acre-feet. The second basin, Grade Stabilization Structure D-17, was constructed on the northwest tributary in 1997. This basin drains ~1,393 acres and had an initial volume of 88.7 acre-feet.

The soils that make up the land play a large part in the erosive nature of the land in the watershed. The primary soil types in the watershed belong to the Marshall-Ponca associations (SCS 1975). The Marshall-Ponca association, formed from the fine particles of loess soils, has low organic matter content, are less productive and have a high runoff potential. This soil association is suited to cultivated crops, as well as grass and windbreak plantings. The erosion potential of all soils in the watershed is high.

1.1.2.2 **Climate:** The climate in the area is classified as moist and sub-humid, characterized by warm summers and cold, dry winters (JJM 1992). Average annual precipitation in the basin is 28.6 inches, with 75 percent occurring between April and September. Intense thunderstorms are common and have produced daily rainfall amounts in excess of 7 inches (JJM 1992).

1.1.2.3 **Demographics:** The information presented below on Omaha's demographics was compiled by the Greater Omaha Chamber of Commerce (GOCC 2000). Omaha currently has a population of about 373,361 and ranks as the nation's 45th largest city. However, the Omaha metro area actually consists of five counties (Douglas, Sarpy, Cass and Washington counties in Nebraska and Pottawattamie County in Iowa) with population of 693,900. Within a 50-mile radius of Omaha resides a population of over one million.

Omaha has shown steady population growth for the past five decades and the Omaha area alone has increased 8.5% since 1990. Steady growth of the five-county Omaha metropolitan area population is expected to continue.

1.1.2.4 **Land Uses:** The area around Standing Bear Lake had historically been undeveloped, with open/undeveloped, cropland and wooded comprising the majority of land use in the watershed (JJM 1992). However, urbanization of the watershed is occurring from the lake in westward direction. Land uses within the watershed were updated through field verification in 1999 and a historical comparison is presented in Table 1.1.2.4.

There has been an ~25 percent increase in residential and/or commercial land uses (constructed or under construction), and an ~39 percent reduction in cropland between 1991 and 1999.

Table 1.1.2.4 Land Use Comparison for 1991 and 1999 as Percentage of Watershed

Land Use Category	1991	1999
Cropland	73.3%	34.7%
Residential/Commercial	3.1%	12.7%
Construction Sites	-	14.9%
Pasture/Tree	19.9%	24.6%
Water	3.6%	3.6%
Other	0.1%	9.5%

2.0 Sediment TMDL to Address Sedimentation / Siltation Impairments

2.1 Problem Identification

This section details the extent and nature of the water quality impairments caused by excessive sedimentation (siltation) in Standing Bear Lake.

2.1.1 **Water Quality Criteria Violated and/or Beneficial Uses Impaired:** The *Aquatic Life* – Warmwater Class "A" and *Aesthetics* beneficial uses assigned to Standing Bear Lake (NDEQ 2000b and 2002b) are not being met (impaired) due to excessive sedimentation.

2.1.2 **Data Sources:** Sediment loading estimates for Standing Bear Lake was determined from USACE "as-built" storage capacity data (USACE 1983) and a reservoir capacity study completed by the NDEQ (NDEQ 1998b).

2.1.3 **Water Quality Data Assessment:** Nebraska does not have a numeric water quality standard for sediment, but in 1998 the NDEQ utilized a method to evaluate the severity of sedimentation in reservoirs. This method considers the percent of reservoir multi-purpose pool (e.g., conservation and sediment pool combined) volume loss on an average annual basis. Severity of sedimentation conditions has been classified into four assessment categories:

Substantial - ≥ 0.75%
Moderate - ≥ 0.50 to <0.75%
Slight - ≥ 0.25 to < 0.50%
Minimal - < 0.25%

This criterion is used as the basis for placing reservoirs on the Water Quality Concerns list (Part 5) for sedimentation. Reservoirs documented as having an average annual volume loss greater-than or equal-to 0.75% are classified in the "substantial" category, and subsequently placed on Part 5.

It should be noted, according to the *Methodology for Waterbody Assessment and Developing the 2002 Section 303(d) List of Impaired Waterbodies for Nebraska* (NDEQ 2001) a lake will be listed for sedimentation when the >25% of the original volume has been lost. Sedimentation surveys estimate the volume loss as of 1998 to be approximately 17%. However, during the Community Based Watershed Management Planning process, the public/stakeholders identified sedimentation as a concern. Based upon the public's concern, the CBMPP process and the sedimentation rate being categorized as "substantial", the NDEQ opted to include Standing Bear Lake on the 2002 Section 303(d) list.

2.1.3.1 **Water Quality Conditions:** Based on USACE (1976) "as-built" plans, Standing Bear Lake's multi-purpose pool (elevation - 1,104 ft) storage capacity was 1,504 acre-feet prior at the time of reservoir construction. In 1998, the NDEQ determined the current volume to be ~1,249 acre-feet. This reflects an annual sedimentation rate of ~0.77%.

2.1.3.2 **Severity and Extent of Water Quality Problem:** The average annual multi-purpose pool volume loss in Standing Bear lake is ~0.77%, which falls within NDEQ's highest severity classification category termed "Substantial".

2.1.4 Potential Pollution Sources

2.1.4.1 **Point Sources:** No point sources exist in the Standing Bear Lake watershed.

2.1.4.2 **Nonpoint Sources:** Multiple nonpoint sediment sources have been identified in the Standing Bear Lake watershed. Sources include: sheet and rill erosion, overland runoff from agricultural lands, construction/development areas, and streambank/gully erosion.

2.1.4.3 **Natural Background Conditions:** Although natural sources of sediment and total suspended solids exist, background contributions of sediment were not separated from the total nonpoint source load.

2.2 TMDL Endpoint

The endpoint for the sedimentation TMDL is based on narrative criteria translated to numeric water quality targets and goals established during the community based watershed management planning process. As described below, annual volume loss targets in comparison with current sediment load estimates allowed for the determination of the allowable load (i.e., desired endpoint), and the associated degree of sediment load reduction needed to attain assigned beneficial uses and stakeholder water quality targets.

2.2.1 Criteria for Assessing Water Quality Standards Attainment

2.2.1.1 **Numeric Water Quality Standards Criteria:** As previously outlined in Section 2.1.3, Nebraska does not have a numeric water quality standard for sediment or total suspended solids.

2.2.1.2 **Quantification of Narrative Water Quality Standards Criteria:** The Warmwater Class "A" *Aquatic Life* use is protected through the overall reservoir volume loss and the annual reservoir sedimentation rate utilized by NDEQ for waterbody assessments. In support of the sedimentation assessment criteria, the narrative criteria for the *Aesthetics* beneficial use found in Title 117 states in part "To be aesthetically acceptable, waters shall be free from human-induced pollution which causes floating, suspended, colloidal, or settleable materials that produce objectionable films, colors, turbidity, or deposits" (NDEQ 2002).

2.2.1.3 **Local Stakeholder Defined Criteria:** Local stakeholders established a goal to improve and maintain the lake environment, and pursue development of an aquatic habitat/lake restoration plan (COPRPP 2000). From this qualitative goal and land use sedimentation goals, the annual loading capacity was defined as an annual sedimentation rate of 0.47%.

2.2.2 Selection of Environmental Conditions

There are no "specific environmental or critical conditions" associated with this sediment TMDL because once the pollutant settles in the reservoir it is assumed to have an infinite residence time and is present on a year-round basis.

2.2.3 Waterbody Pollutant Loading Capacity

The loading capacity for this TMDL is defined as the amount of sediment Standing Bear Lake can receive on an annual basis and still meet the assigned beneficial use criteria and established in-lake water quality targets. To achieve an average annual multi-purpose pool volume loss rate of <0.47% the sediment loading capacity for Standing Bear Lake has been set at 10,000 tons/years (a sediment density value of 1,400 was used in the conversion of acre-feet to tons).

2.3 Pollution Source Assessment

For this TMDL, long-term sediment loadings estimates for Standing Bear Lake were first determined from USACE's and NDEQ's area capacity studies (USACE 1996 and NDEQ 1998b). Secondly, the average annual sediment load based on existing watershed conditions in 1998 was estimated by applying the Generalized Watershed Loading Functions (GWLF) model (Haith et al. 1996).

2.3.1 Existing Sediment Load

Area capacity studies (USACE 1996 and NDEQ 1998b) revealed the long-term average annual sediment load delivered to Standing Bear Lake has been ~16,227 tons/year based on realized storage loss changes from 1976 to 1998. Under 1998 watershed conditions (i.e., land use, structural changes, etc.) the GWLF model estimated the average annual sediment load from sheet and rill erosion at ~4,544 tons/year (LTI 2000). In 1998 there was no discharge from the newly constructed dam (Grade Stabilization Structure D-17) on the north tributary draining into Standing Bear Lake. Once filled however, the total load in following years was expected to be slightly higher (LTI 2000).

2.3.2 Deviance From Loading Capacity

Long-term area capacity studies documented Standing Bear Lake as having an average annual volume loss of 0.77%, which is greater-than the 0.75% maximum identifying a water quality concern (NDEQ 2001). Based on this data, to achieve the identified average annual volume loss <0.47%, the long-term sediment load (16,227 tons/year) being delivered to the lake must be $\leq$10,000 tons/year. Loading estimates based on 1998 watershed conditions showed the current average annual load to be ~4,544 tons/year; well below the 10,000 tons/year average needed to meet 0.47% target.

2.3.3 Identification of Pollutant Sources

Since there are no point source discharges in the Standing Bear Lake watershed, nonpoint sediment source identification and quantification was completed through application of the GWLF (*USLE*) model (LTI 2000). Modeling efforts required that Standing Bear Lake's 3,840 acre watershed be delineated into 8 subwatersheds (Figure 2.3.3) where a multitude of site specific parameters (e.g., land use, acres, conservation measures, land slope, soil erodibility, soil tillage practices, etc.) were documented.

2.3.3.1 Nonpoint Sources of Sediment

Sediment generated by land use type as estimated by the GWLF model is presented in Table 2.3.3.1. Eleven contributing land uses were recognized as occurring in the watershed. The intent of the modeling exercise was to identify the sediment contributors by land type and subwatershed. Land in row crops and under construction were the two largest contributors of the gross sediment load accounting for 46% and 48% respectively.

2.3.4 Linkage of Sources to Endpoint

The average annual sediment load of ~4,544 tons delivered to Standing Bear Lake has been determined to originate entirely from nonpoint sources. Under the current (1998) watershed conditions this TMDL's desired endpoint is already being met. Having met this TMDL's endpoint is a direct result of the implementation and associated trapping efficiency of the two large basins above Standing Bear Lake. However, the waterbody has been included on the Nebraska Section 303d List of Impaired Waters and will remain until the "calculated" sedimentation rate is below the impairment threshold.

2.4 Pollutant Allocation

A TMDL is defined as:

TMDL = Loading Capacity = WLA + LA + Background +MOS

As stated previously in Section 2.3.2, the loading capacity for Standing Bear is 10,000 tons/year. Since the estimated average annual sediment load of ~4,544 tons is well below the stated loading capacity, the required allocations are as follows:

2.4.1 Waste Load Allocation

No point sources of sediment exist in the watershed therefore the wasteload allocations (WLA) will be "zero" (0 tons/year).

2.4.2 Load Allocations

The Load Allocation (LA) distributed among the nonpoint sources will be ~4,544 tons/year. Base flows carry indiscernible amounts of sediment and thus natural background will not be separated from the load allocation.

2.4.3 Margin of Safety

The margin of safety (MOS) associated with this sediment TMDL will be: the assessment of reservoir sedimentation is based on overall volume loss, annual sedimentation rate and future land use scenario. The current sedimentation rate of ~0.10%/year (LTI 2000) is well below the 0.75%/year sedimentation rate that triggers water quality concerns as identified in the *Methodology for Waterbody Assessment and Developing the 2002 Section 303(d) List of Impaired Waterbodies for Nebraska* (NDEQ 2001). The difference between the allowable (10,000 tons/year) and expected sediment loads (4,544 tons/year) delivered to Standing Bear Lake is 5,456 tons/year that will be allocated to the MOS.

Figure2.3.3 Standing Bear Lake's Subwatershed Delineation for Modeling

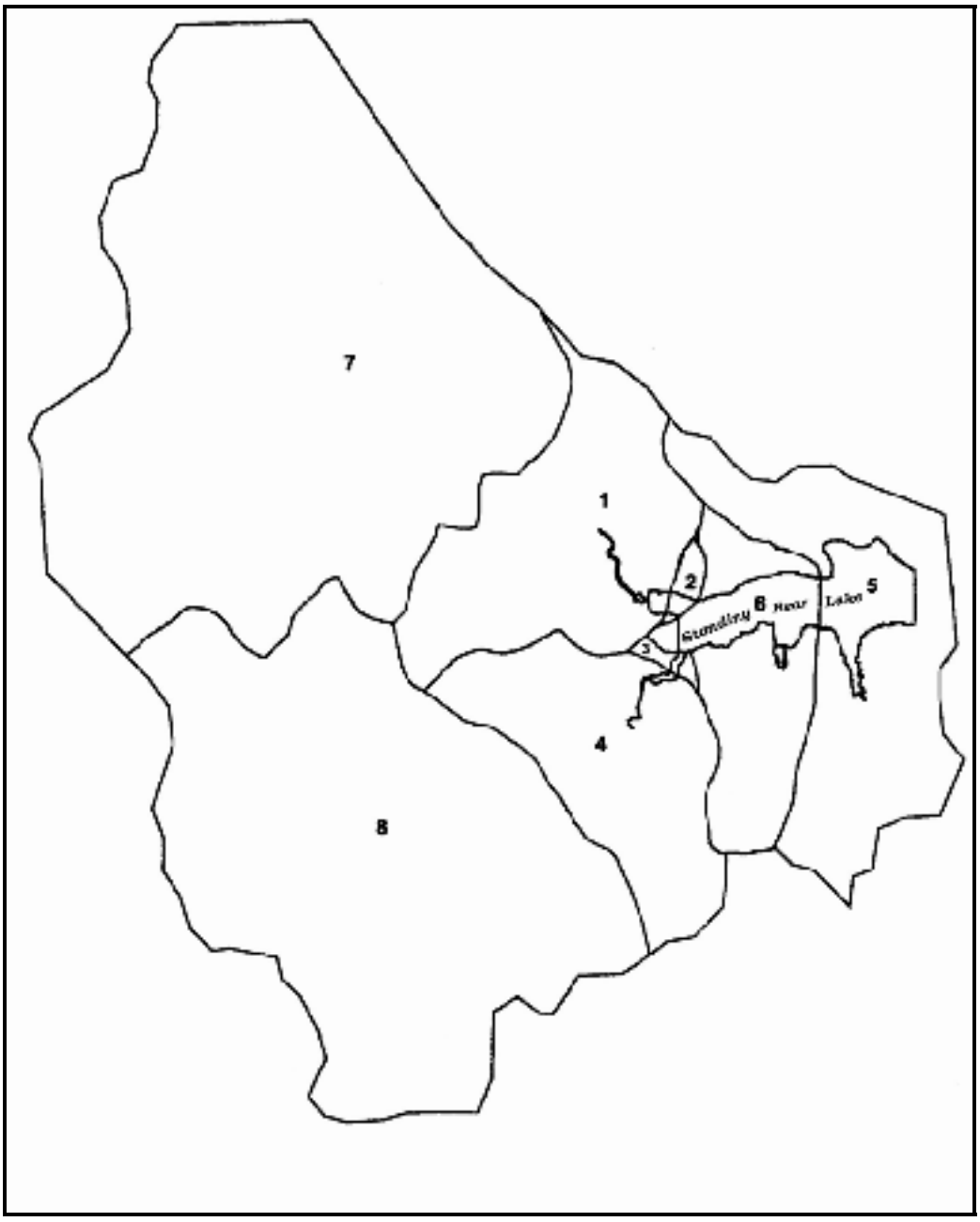

Table 2.3.3.1 Modeled Sediment Sources by Land Use

Land Use Category	Total Area Modeled (acres)	Annual Gross Sediment Load (% of Total)
Acreage/Farmstead	108.7	<1%
Tree	47.0	<1%
Corn	415.1	19%
Terraced Corn	261.9	6%
Beans	321.2	15%
Terraced Bean	227.3	5%
Pasture	32.1	<1%
Grass	462.1	2%
Grass/Tree	415.1	1%
Alfalfa	135.9	2%
Construction	583.2	48%
Water/Basins	39.6	0%
Roads	244.6	0%
Residential	439.8	0%
Industrial/Commercial	59.3	0%
Cemetery	2.5	0%
TOTAL	3,795.4	100%

3. Nutrient TMDL to Address Nutrient and Low Dissolved Oxygen/Organic Enrichment Impairments

3.1 Problem Identification

Standing Bear Lake was placed on the 1998 Section 303d list as being impaired by low dissolved oxygen/organic enrichment and in 2002 for nutrients with a dissolved oxygen being identified as a water quality concern. In-lake conditions indicate that accelerated eutrophication caused by excessive nutrient loading is the primary reason. The linkage between accelerated eutrophication and water quality impairments has been repeatedly documented (USEPA 1999). Eastern Nebraska reservoirs classified as being eutrophic or hypereutrophic are generally high in phosphorus, particularly in watersheds that produce high sediment yields. Standing Bear Lake watershed modeling and in-lake conditions have resulted in phosphorus being the targeted parameter of concern. The following section details the extent and nature of the water quality impairments related to accelerated eutrophication in Standing Bear Lake.

3.1.1 Water Quality Impairments: Standing Bear Lake was included on the 2002 Section 303(d) list as being impaired by excessive nutrients. Excessive nutrients can lead to accelerated algae growth (algal blooms) that degrade a waterbodies aesthetic quality and may cause dissolved oxygen problems. Low dissolved oxygen was included as a water quality concern. Phosphorus was selected as the nutrient/parameter of concern because past monitoring has indicated eastern Nebraska lakes to be phosphorus limited.

3.1.2 Data Sources: The NDEQ and USACE have collected various water quality data on a semi-regular basis in Standing Bear Lake from 1990 to 1998. The existing data set included dissolved oxygen, temperature, conductivity, and pH profiles and measurements of Secchi transparency, alkalinity, chlorophyll *a*, phaeophyton *a*, ammonia, total Kjeldahl nitrogen, nitrate/nitrite nitrogen, dissolved ortho-phosphorus, total phosphorus, total suspended solids, calcium, magnesium, potassium, sodium, chloride, sulfate, total organic carbon, dissolved metals, pesticides and fecal coliform. These data were primarily collected at the deepwater location in Standing Bear Lake. Additional Secchi depth measurements were collected at three locations (deepwater and the two "arms" of the lake) in 1998. A summary of specific parameters of concern is presented in the attachments: *Proposed TMDL for Standing Bear Lake* (LTI 2000) and *A Community-Based Watershed Management Plan for Standing Bear Lake* (COPRPP 2000).

3.1.3 Water Quality Data Assessment: Beneficial use assessment procedures utilized for dissolved oxygen require that concentrations be measured in a "top-to-bottom" profile above the stratified layer. Measurements are then averaged and compared to the 1-day minimum aquatic life criteria of 5.0 mg/l, applicable from April 1 to September 30 (NDEQ 2002). At least 10 data points obtained in the previous 5 years was required for the assessment to be considered "monitored". Should greater than 10% of the profile averages fall below the criteria, the waterbody was considered to be partially supporting the *Aquatic Life* WWA beneficial use and thus included on the Section 303(d) list. The 10% exceedance rate is based upon meeting the minimum confidence established by NDEQ. The number of exceedances necessary to "list" a waterbody is determined using the binomial distribution as described in the *Methodology for Waterbody Assessment and Developing the 2002 Section 303(d) List of Impaired Waterbodies for Nebraska* (NDEQ 2001).

Nebraska currently does not have numeric water quality criteria for nutrients however; a biomass trophic state index (TSI) (Carlson 1977; Carlson and Simpson 1996) is used as the metric for evaluating this source/stressor. TSI's calculated from transparency (secchi depth), chlorophyll *a*, and total phosphorus concentration data, were utilized to infer whether algal growth was nutrient or light limited (if the three indices are approximately equal, it can be inferred that algal growth is phosphorus limited (USEPA 1999)). Also, the average of the three TSI scores is used as a single measure of lake conditions (e.g., oligotrophic, mesotrophic, eutrophic or hypereutrophic) as described in Carlson and Simpson (1996). The following classification is used to interpret the TSI:

Trophic State Index Score	Trophic Status	Assessment Criteria	NDEQ Beneficial Use Attainment Status
<40	Oligotrophic	2 of 3 parameters	Full Support
>35 but <45	Mesotrophic	2 of 3 parameters	Full Support
>45	Eutrophic	2 of 3 parameters	Full Support
>60	Hypereutrophic	2 of 3 parameters	Partial Support

3.1.3.1 Water Quality Conditions: Twelve (12) growing season (May through September) dissolved oxygen profiles were available for Standing Bear Lake from 1997 to 2001. Assessments of the profiles indicated two (2) of the average concentrations were less than the 5.0 mg/l criteria for a 16.6% excursion rate. The number of exceedances did not meet the minimum confidence level necessary to deem the waterbody as impaired and place on the 303(d) list. However, because the exceedance rate was >10% the waterbody was identified as a water quality concern.

Trophic State Indices scores for Standing Bear Lake using average growing season in-lake data collected from 1995 to 2001 include:

Parameter	TSI Score
Secchi depth (meters)	65.6
Chlorophyll *a* (mg/m^3)	63.0
Total Phosphorus (µg/l)	63.0
Mean TSI	**63.9**

With a mean TSI score of 63.9, the waterbody is considered hypereutrophic and because at least 2 of the 3 parameters are greater than the hypereutrophic threshold, the waterbody is considered partially supporting the aesthetic and aquatic life beneficial uses. The TSI scores for each of the parameters are similar which is a demonstration that the waterbody system is phosphorus limited and thus the parameter targeted for reduction. It should be noted that although phosphorus is the targeted parameter of concern, implementation of controls should also result in a reduction of the nitrogen contributions. It should be noted, the waterbody was retained on the 2002 Section 303(d) list based upon the lack of sufficient data to de-list.

3.1.4 Potential Pollution Sources

3.1.4.1 **Point Sources:** No point sources exist in the Standing Bear Lake watershed.

3.1.4.2 **Nonpoint Sources:** Multiple nonpoint sediment sources have been identified in the Standing Bear Lake watershed. Sources include: sheet and rill erosion, overland runoff from agricultural lands, construction/development areas, and streambank/gully erosion.

3.1.4.3 **Natural Sources:** Natural background/sources was based upon the contribution of phosphorus as estimated by EUTROMOD modeling techniques.

3.2 TMDL Endpoint

The endpoint for the nutrient and dissolved oxygen TMDL is based on both narrative and numeric criteria and stakeholder water quality goals. As described below, phosphorus loading targets in comparison with current load estimates, allowed for the determination of an allowable load (i.e., desired endpoint), attain full support designation and the stakeholder water quality goals.

3.2.1 Criteria for Assessing Water Quality Standards Attainment

3.2.1.1 **Numeric Water Quality Standards Criteria:** The 1-day minimum dissolved oxygen criteria of 5.0 mg/l associated with the WWA – Aquatic life beneficial use is the applicable numeric water quality criteria.

3.2.1.2 **Quantification of Narrative Water Quality Standards Criteria:** As previously outlined in Section 3.1.3, Nebraska does not have numeric water quality standards for nutrients. However, Nebraska's water quality standards for "Aesthetics" states in part, "To be aesthetically acceptable, waters shall be free from human-induced pollution which causes floating, suspended, colloidal, or settleable materials that produce objectionable films, colors, turbidity, or deposits (NDEQ 2002a).

The application of the "Aesthetics" beneficial use is through the assessment of a lake's trophic status using Carlson's trophic state index (TSI) as described in Section 3.1.3. In order for a water body to achieve a "full support status", 2 of 3 TSI parameters must be less than 60.

Ultimately, the public will decide if a waterbody is aesthetically acceptable or un-acceptable. Therefore, the goals/endpoints used for these TMDLs (nutrients and dissolved oxygen) have been established in part through the development of the Standing Bear Lake Community Based Watershed Management Plan.

3.2.1.3 **Local Stakeholder Defined Criteria:** Through stakeholder meetings held in the Standing Bear Lake watershed, general in-lake water quality goals were established (COPRPP 2000). The public established general goals related to improving and protecting the aquatic habitat and improving the water clarity, such that all the desired recreational, aquatic and aesthetic beneficial uses are not degraded.

3.2.2 Selection of Environmental Conditions

The "critical condition" for which this nutrient TMDL applies is the entire year. An annual loading period was utilized in modeling Standing Bear Lake's assimilative capacity and for estimating loading reductions necessary to meet in-lake water quality targets. This approach also takes into consideration that nutrients being lost from the water column and trapped in the bottom sediments have the potential to re-enter the water column at a later time. However, implementation of non-point source controls will target those times when a large percent of the loading is occurring.

3.2.3 Waterbody Pollutant Loading Capacity

The loading capacity for this nutrient TMDL is defined as the amount of phosphorus Standing Bear Lake can receive on an annual basis and still meet the applicable water quality criteria, assigned beneficial use criteria and established in-lake water quality goals. Utilizing the EUTROMOD (Reckhow 1992) model, the meet the secchi, chlorophyll *a* and phosphorus goals, the loading capacity for phosphorus, for Standing Bear Lake is 778 lbs/year (352.7 kg/year).

3.3 Pollution Source Assessment

For this nutrient TMDL, the phosphorus loading was estimated using a combination of the EUTROMOD Model and in-lake data.

3.3.1 Existing Pollutant Load

The average annual phosphorus load is estimated to be 1,191lbs/year (540 kg/year). This value was estimated using the EUTROMOD models and calibrated to long-term, in-lake conditions.

3.3.2 Deviance From Loading Capacity

The targeted waterbody loading capacity for phosphorus, to meet the in-lake goals is 778 lbs/year. The modeled load is 1,191lbs/year. Therefore, the loading capacity is being exceeded by 413 lbs/year and to achieve the loading capacity, a 34.7% reduction from the current (total) phosphorus load is needed.

3.3.3 Identification of Pollutant Sources

Because no point sources have been identified in the Standing Bear Lake watershed, the pollutant load is believed to originate from nonpoint sources. Typically, areas with high sediment yields also produce significant phosphorus loads. The 1999 land uses indicate approximately 75% of the watershed is defined as agriculture (34.7%), pasture/tree (24.6%) or construction sites (14.9). As the metropolitan area of Omaha expands, the transition from agriculture and pasture to construction site and eventually residential areas in expected to continue. As well, stream bank, gully and shoreline erosion should be considered phosphorus sources.

3.3.3.1 Nonpoint Sources of Phosphorus

Table 3.3.3.1 describes the six contributing land uses that were recognized as occurring in the watershed using both 1991 and 1999 estimates. Crop land and construction sites have been shown by past analysis and sampling to be two of the largest contributors of the gross phosphorus load.

Table 3.3.3.1 Comparison of 1991 and 1999 Land Uses as Percent of theWatershed

Land Use Category	1991	1999
Crop Land	73.3	24.7
Residential Commercial	3.1	12.7
Construction Sites	--	14.9
Pasture/Tree	19.9	24.6
Water	3.6	3.6
Other	0.1	9.5

3.3.4 Linkage of Sources to Endpoint

The average annual phosphorus load of 1,191 lbs to Standing Bear Lake has been determined to originate entirely from nonpoint sources. To meet the desired endpoint for the TMDL, the annual nonpoint source phosphorus contributions from the watershed must be must be reduced 37% (413 lbs) to 745lbs/year.

3.4 Pollutant Allocation

A TMDL is defined as:

$$\text{TMDL} = \text{Loading Capacity} = \text{WLA} + \text{LA} + \text{Background} + \text{MOS}$$

As stated previously in Section 3.3.2, the loading capacity for Standing Bear is ≈778 lbs/year. To achieve the defined phosphorus loading capacity the required allocations are contained in the following sections.

3.4.1 Waste Load Allocation

No point sources of phosphorus exist in the watershed therefore the wasteload allocations (WLA) will be “zero” (0 lbs/year).

3.4.2 Load Allocations

The phosphorus load allocation distributed among the nonpoint sources within the watershed will be ≈745 lbs/year (338 kg/year).

3.4.3 Natural Background

Utilizing annual precipitation, waterbody surface area and precipitation phosphorus concentration the natural background load of phosphorus was determined to be approximately 33.7 lbs/year (15.3 kg/year).

3.4.4 Margin of Safety

The margin of safety for the nutrient TMDL will be: phosphorus can be discharged from the Standing Bear Lake/Reservoir outlet without being utilized. While this reduction is realized in the system, the TMDL will not account for this and assume the phosphorus load delivered to the lake remains available for algae production.
As well, implementation of two large basins and continual conversion of agricultural lands to residential continue to result in significant loading reductions to Standing Bear Lake that is expected to result in beneficial use attainment.

3.4.5 Nutrient (Phosphorus) TMDL Summary

TMDL/Waterbody Loading Capacity = 0 lbs/year (WLA) + 745 lbs/year (LA) + 33.7 lbs/year (Natural Background) + Implicit Margin of Safety

4.0 Implementation Plan

The implementation plan for the Standing Bear Lake TMDL is unique because the required activities targeted at reducing the NPS nutrient/sediment loadings are presently occurring, independent of this TMDL. A community-based implementation plan has been developed though a public participation process (see attached copy of *"A Community-Based Watershed Management Plan for Standing Bear Lake*", COPRPP 2000) and a manual entitled *"Best Management Practices for Construction Sites: Cunningham, Standing Bear, and Zorinsky Lake Watersheds"* (COPRPP 1999) was developed and adopted for the Standing Bear Lake watershed.

5.0 Future Monitoring

Monitoring of Standing Bear Lake will be conducted in the future to determine if the water quality is improving, degrading or remaining status quo. As well, monitoring will be conducted to evaluate the effectiveness of implemented best management practices (BMPs). The NDEQ has entered into an agreement with the USACE whereby the USACE will conduct monthly monitoring throughout the growing season and forward the results to NDEQ for assessment. Also, the USACE will periodically evaluate the impacts of sedimentation (bathymetry). Along with the USACE monitoring, NDEQ may periodically conduct monitoring to evaluate the effectiveness of BMPs.

6.0 Public Participation

The availability of the TMDLs in draft form was published in the Omaha World Herald and Lincoln Journal Star with the public comment period running from Mat 10, 2003 to June 13, 2003. These TMDLs were also made available to the public on the NDEQ's Internet site and announcement letters were mailed to interested stakeholders.

As a result of the public notice, comment letters were received from the Nebraska Pork Producers Association (NPPA) and the United States Fish and Wildlife Service (USFWS). No action or response was required as a result of the comments made by the NPPA. Comments made by USFWS pertained to future monitoring and the delisting of waterbodies as impaired by atrazine. The response to comments (included with the submittal package) explains the future monitoring objectives and expected parameters and defers the atrazine comment to the water quality standards program. No changes were made to the TMDLs as a result of the USFWS comments.

7.0 References

Carlson, R.E. 1977. A trophic state index for lakes. *Limnology and Oceanography* 25:378-382.

7.0 References (continued)

Carlson, R.E., and J. Simpson. 1996. *A coordinator's guide to volunteer lake monitoring methods*. North American Lake Management Society and the Educational Foundation of America.

COPRPP 1999. Best Management Practices for Construction Sites: Cunningham, Standing Bear, and Zorinsky Lake Watersheds. Omaha Parks, Recreation and Public Property. Omaha, Nebraska.

COPRPP 2000. A Community-Based Watershed Management Plan for Standing Bear Lake. Omaha Parks, Recreation and Public Property. Omaha, Nebraska.

GOCC 2000. Metro Omaha Statistical Profile – 2000. Greater Omaha Chamber of Commerce. Omaha, Nebraska.

Haith, D.A., R. Mandel, and R.S. Wu. 1996. GWLF: *Generalized Watershed Loading Functions Version 2.0 User's Manual*. Department of Agricultural and Biological Engineering, Cornell University, Ithaca, NY.

JJM 1992. Volume 5: Diagnostic/Feasibility Study for Standing Bear Lake, Douglas County, Nebraska. James M. Montgomery, Consulting Engineers, Inc.

LTI 2000. Proposed TMDL for Standing Bear Lake. Limno-Tech, Inc. Ann Arbor, Michigan.

NDEQ 1998a. 1998 Nebraska Water Quality Report. Nebraska Department of Environmental Quality, Water Quality Division. Lincoln, Nebraska.

NDEQ 1998b. 1998 Volume Survey Data - un-published report. Nebraska Department of Environmental Quality, Water Quality Division. Lincoln, Nebraska.

NDEQ 2002. Title117 – Nebraska Surface Water Quality Standards. Nebraska Department of Environmental Quality, Water Quality Division. Lincoln, Nebraska.

NDEQ 2000. 2000 Nebraska Water Quality Report. Nebraska Department of Environmental Quality, Water Quality Division. Lincoln, Nebraska.

NDEQ 2001. Methodology for Waterbody Assessment and Developing the 2002 Section 303(d) List of Impaired Waterbodies for Nebraska. Nebraska Department of Environmental Quality, Water Quality Division. Lincoln, Nebraska.

NDEQ 2002a. 2002 Nebraska Water Quality Report. Nebraska Department of Environmental Quality, Water Quality Division. Lincoln, Nebraska.

NDEQ 2002b. 2002 Section 303(d) List of Impaired Waters. Nebraska Department of Environmental Quality. Lincoln, NE.

Reckhow, K.H. 1992 EUTROMOD Nutrient Loading and Lake Eutrophication Model. Duke University School of the Environment. Durham, North Carolina.

SCS 1975. Soil Survey of Douglas County and Sarpy Counties, Nebraska. U.S. Department of Agriculture Soil Conservation Service, USDA, Washington DC.

USACE 1976. Topographic map and design plans for Standing Bear Lake - Unpublished Document. United States Army Corps of Engineers, Engineering Division, Omaha District, Omaha, Nebraska.

USACE 1983. Reservoir Capacity Table for Site 18 - Unpublished Report. United States Army Corps of Engineers, Engineering Division, Omaha District, Omaha, Nebraska.

USACE 1996. Sedimentation Conditions at the Papio Creek Projects near Omaha, Nebraska, 1974 – 1994. River and Reservoir Engineering Section, Hydraulic Engineering Branch, Engineering Division, United States Army Corps of Engineers, Omaha District, Omaha, Nebraska.

USEPA 1997.Compendium of Tools for Watershed Assessement and TMDL Development. United States Environmental Protection Agency. EPA841-B-97-006.

USEPA 1999. Protocol for Developing Nutrient TMDLs. United States Environmental Protection Agency. Office of Water, 4503 F, Wahington, DC.

Appendix A – Phosphorus Load Estimation Based on In-lake Phosphorus Concentration

Standing Bear Reservoir	Input data in green cells		Phosphorus (mg/l)	Chlorophyll a	Secchi Depth	Secchi Depth (inches)
Surface Acres (acres)	104	Monitored In-lake Value	0.0600	27.1	0.68	26.8
Lake Volume (ac-ft)	1249	Predicted	0.0600	12.30	0.595	23.4
Inflow (ac-ft/year)	2924	% Similar	1.00	0.45	0.88	
Inflow (cfs)						
Annual Precipitation	28.6		TSI - phosphorus	TSI - chlorophyll *a*	TSI - secchi	MEAN TSI
Watershed P Loading (lbs)	1157	Monitored In-lake Value	63.2	63.0	65.6	63.9
Detention Time (years)	*0.43*	Predicted	63.2	55.2	67.5	62.0
Lake Volume (10^6 m^3)	*1.541*	% Similar	1.00	0.88	0.97	0.97
Volumetric Water Load (10^6 m^3/yr)	*3.607*					
Mean Depth (ft)	*12.01*		Watershed load to meet in-lake p concentration (lbs)	Watershed load to meet in-lake Chlorophyll *a* (lbs)	Watershed load to meet in-lake secchi (lbs)	
Mean Depth (m)	*3.661*		1157			
Watershed P Loading (kg)	525		Load Summary			
Precip P Load (kg)	*15.3*		Minimum			
Septic P Load (kg)			Mean			
WWTF P Load (kg)			Median			
Total P Loading (kg)	*540*		Maximum			
Total P Loading (lbs)	*1190.7*					
Expected Total P-in	*0.150*					

Appendix B – EUTROMOD Model Output to Meet Beneficial Use Full Support

Standing Bear Reservoir	Input data in green cells		Phosphorus (mg/l)	Chlorophyll a	Secchi Depth	Secchi Depth (inches)
Reduction %	35.6	Predicted	0.0480	10.97	0.689	27.1
Lake Volume (ac-ft)	1249	Water Quality Goals	0.0480	20.00	0.99	39
Surface Acres (acres)	104	% Similar	1.00	0.55	0.70	
Detention Time (years)	0.43					
Watershed P Loading (lbs)	1157		TSI - phosphorus	TSI - chlorophyll *a*	TSI - secchi	MEAN TSI
Reduced Watershed Load (lbs)	*745.1*	Predicted	60.0	54.1	65.4	59.8
Volumetric Water Load (10^6 m^3/yr)	*3.607*	Water Quality Goals	60.0	60.0	60.1	60.0
Lake Volume (10^6 m^3)	*1.541*	% Similar	1.00	0.90	0.92	1.00
Mean Depth (ft)	*12.01*					
Mean Depth (m)	*3.661*		Watershed load Reduction to meet p concentration water quality goal (lbs)	Watershed load reduction to meet Chlorophyll *a* water quality goal (lbs)	Watershed load reduction to meet secchi measurement goal (lbs)	
Reduced Watershed Load (kg)	337.98					
Precip P Load (kg)	*15.3*		Reduction Summary			
Septic P Load (kg)	*0.0*		Minimum			
WWTF P Load (kg)	*0.0*		Mean			
Total Reduced P Loading (kg)	*353.3*		Median			
Total Reduced P Loading (lbs)	*778.8*		Maximum			
Expected Total P-in	*0.098*					